Publication number : 10-174924

Date of publication of application : 30.06.1998

Int.Cl. B05C 11/00 B05C 5/00

Application number : 08-337094

Applicant : HITACHI TECHNO ENG CO LTD

Date of filing : 17.12.1996

Inventor :

ISHIDA SHIGERU

SAITO MASAYUKI

SANKAI HARUO

PASTE APPLYING APPARATUS

[Abstract]

PROBLEM TO BE SOLVED: To measure a drawn paste pattern in any shape at high speed and high precision by carrying out image distinction of a region on a substrate where a slit mark is projected by radiating light through a slit and computing the height of the paste pattern from the paste pattern and the slit mark.

SOLUTION: While a paste spraying outlet being set to face to a substrate 24, a nozzle 13 is moved in X, Y-directions corresponding to a paste pattern data and a paste is sprayed out of the paste spraying outlet of the nozzle 13 and the undulation of the surface of the substrate is measured based on the data of the gap between the paste spraying outlet of the nozzle 13 and the surface of the

substrate actually measured by a range meter 14 and the set height of the nozzle 13 from the surface of the substrate is kept constant by a servo-motor 12. Light which is slantingly passed through a cross-shape slit is radiated to the substrate from a light source 22, the reflected light radiated through the slit is received by an image recognition camera 23 and photographed, and the height of the paste pattern is detected.

[Claim(s)]

[Claim 1] A paste coating device carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, the paste coating device comprising: a light source formed on a support member of the nozzle, for irradiating slit light onto the paste pattern formed on the substrate, such that the relative position relation between the nozzle and the substrate is varied; an image recognizing unit for image-recognizing the area onto which the slit mark is irradiated through the slit light onto the substrate; and an image processing unit for obtaining the height of the paste pattern from the paste pattern recognized by

the image recognizing unit and from the image of the slit mark irradiated to cross the paste pattern.

[Claim 2] The paste coating device as claimed in claim 1, wherein the light source is formed on the support member of the nozzle for irradiating the slit light onto the paste pattern at an angle of depression of 45 degrees with respect to the surface of the substrate, the image recognizing unit is formed on the support member of the nozzle for recognizing the image of the slit mark at a vertical position with respect to the surface of the substrate, and the image processing unit determines the height of the paste pattern to which the slit light is irradiated to be the distance from the highest position of image of the paste pattern to which the slit light is irradiated to the intersection between the highest position of the image and the line extended from the straight line of the image connecting two positions of the paste pattern at which the end peripheries of the paste pattern abut against the substrate in the irradiation direction of the slit light.

[Claim 3] The paste coating device according to claim 2, wherein if the slit mark formed by the irradiation of the slit source is cross-shaped, the image processing

unit sets as the highest position of the paste pattern an image distance between an image position where an axis of the slit light intersects the central portion of the paste pattern in a width direction thereof and an image position where the axis of the slit light intersects the surface of the substrate.

[Title of the invention]

PASTE APPLYING APPARATUS

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a paste coating device that is carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, and more particularly, to a paste coating device that can at once check whether the paste pattern that is formed on the substrate has a desired shape.

[0002]

[Description of the Prior Art]

As disclosed in Japanese Patent Laid-Open Publication No. Hei 7-275770, a paste coating device according to the prior art that is carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, the paste pattern device including: a distance meter for measuring the distance between the outlet of the nozzle and the substrate facing each other; a moving unit for moving the distance meter and the nozzle in a relative relation with respect to the surface of the substrate; and a section capturing unit for calculating coating height and coating width of the paste pattern formed on the surface of the substrate with the measured data of the distance meter upon the relative movement.

[0003] In more detail, the distance meter is provided at the lower end thereof with a triangular cut portion that has two inclined surfaces facing against each other, the one inclined surface having a light emitting diode thereon and the other having a plurality of light receiving diodes thereon. The nozzle is positioned under the triangular cut portion of the distance meter. The light emitting diode serves to irradiate light on the area placed just under the outlet of the nozzle, and the reflected light from the area is received through any of the plurality of light receiving diodes. As the nozzle and the distance meter are moved together with respect to the substrate, if the distance (interval) between the outlet of the nozzle and the surface of the substrate is varied, the light receiving diodes that take the reflected light are varied. Thus, the position of the light receiving diode taking the reflected light is checked such that the distance between the outlet of the nozzle and the surface of the substrate distance meter is measured by using a non-contact triangulation method.

[0004]

[Problem(s) to be Solved by the Invention] According to the prior art, since the light emitting diode emits directional light, which may be not reflected toward the direction where the light receiving diodes are arranged, according to the shape of the paste pattern formed on the surface of the substrate. Thus, the reflected light from the paste pattern cannot be taken by any light receiving diode, and in this case, it is impossible to measure the distance between the outlet of the nozzle and the surface of the substrate.

[0005] Moreover, since the light emitting diode emits dot-shaped beam light, when the nozzle and the distance meter are moved together with respect to the substrate, the interval between the distance meter and the substrate is slightly misaligned by the vibration generated upon the movement, thereby making it impossible to measure the height of the paste pattern with precision. If the measurement of the height is to be obtained preciously, the relative movement velocity between the distance meter and the substrate has to be low, but in this case, the efficiency of working tact becomes undesirably lowered.

[0006] Accordingly, the present invention has been made in view of the above-mentioned problems occurring in the prior art, and an object of the present invention is to provide a paste coating device that can measure all various paste patterns formed on the substrate with precision and at a substantially high velocity, irrespective of the shapes of the paste patterns.

[0007]

[Means for Solving the Problem] To achieve the above object, according to an aspect of the present invention, there is provided a paste coating device carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, the paste coating device including: a light source formed on a support member of the nozzle, for irradiating slit light onto the paste pattern formed on the

substrate, such that the relative position relation between the nozzle and the substrate is varied; an image recognizing unit for image-recognizing the area onto which the slit mark is irradiated by the irradiation of the slit light onto the substrate; and an image processing unit for obtaining the height of the paste pattern from the paste pattern recognized by the image recognizing unit and from the image of the slit mark irradiated to cross the paste pattern.

[0008] In more detail, the light source is formed on the support member of the nozzle for irradiating the slit light onto the paste pattern at an angle of depression of 45. degree. with respect to the surface of the substrate, the image recognizing unit is formed on the support member of the nozzle for recognizing the image of the slit mark with at a vertical position with respect to the surface of the substrate, and the image processing unit determines as the height of the paste pattern to which the slit light is irradiated the distance from the highest position of image of the paste pattern to which the slit light is irradiated to the intersection between the highest position of the image and the line extended from the straight line of the image connecting two positions of the paste pattern at which the substrate

abuts the end peripheries of the paste pattern in the irradiation direction of the slit light.

[0009]

[Embodiment of the Invention] Hereinafter, an explanation of the paste coating device according to the preferred embodiment of the present invention is given with reference to the accompanying drawings.

[0010] FIG. 1 is a perspective view showing the structure of a paste coating device according to the present invention. Reference numeral 1 denotes a mount, 2a and 2b denote substrate returning conveyors, 3 denotes a support stand, 4 denotes a substrate suction plate, 5 denotes a θ–direction movement table, 6a and 6b denote X-axis movement tables, 7 denotes a Y-axis movement table, 8 denotes a servo motor, 9 denotes a Z-axis movement table, 10 denotes a servo motor, 11 denotes a ball screw, 12 denotes a servo motor, 13 denotes a paste storage receptacle (syringe), 14 denotes a distance meter, 15 denotes a support plate, 16a and 16b denote an image recognizing camera, 17 denotes a control unit, 18 denotes a monitor, 19 denotes a keyboard, 20 denotes a personal computer body

provided with an external memory unit, 21 denotes a cable, 22 denotes a light source, and 23 denotes an image recognizing unit.

[0011] As shown in FIG. 1, the substrate returning conveyors 2a and 2b are ascendably disposed in parallel relation to each other in a direction of an axis X on the mount 1, for returning a substrate which is not shown to the front of the drawing from the inside thereof, that is, for returning the substrate horizontally in the direction of the axis X. Further, the support stand 3 is located on the mount 1, and the substrate suction plate 4 is placed on the support stand 3, placing the θ–direction movement table 5 between the substrate suction plate 4 and the support stand 3. The θ–direction movement table 5 serves to rotate the substrate suction plate 4 in the θ direction that is made by the rotation of an axis Z.

[0012] Further, the X-axis movement tables 6a and 6b are disposed in parallel relation to each other with respect to the direction of the axis X at the outer sides of the mount 1 separated by a given distance from the substrate returning conveyors 2a and 2b, and the Y-axis movement table 7 is disposed horizontally between the X-axis movement tables 6a and 6b. The Y-axis movement table 7 is

returned horizontally to its original position by the forward rotation or the rotation of the backward rotation (forward-backward rotation) of the servo motor 8 mounted on the X-axis movement table 6a. The Z-axis movement table 9 that is moved in the direction of an axis Y by the forward and backward rotation of the ball screw 11 by the driving of the servo motor 10 is disposed on the Y-axis movement table 7.

[0013] The support plate 15 is located on the Z-shaft movement table 9, for fixedly supporting the paste storage receptacle 13 and the distance meter 14. The servo motor 12 serves to guide the paste storage receptacle 13 and the distance meter 14 in the direction of the axis Z through the driving part of a linear guide (which is not shown) mounted on the support plate 15. The paste storage receptacle 13 is detachably mounted on the driving part of the linear guide.

[0014] Further, the mount 1 is provided on the ceiling plate thereof with the image recognizing cameras 16a and 16b that are located upwardly, for adjusting the position of the substrate.

[0015] The mount 1 is provided at the inside thereof with the control unit 17 that controls the servo motors 8, 10, and 12, connected to the monitor 18, the keyboard 19 and the PC body 20 through the cable 21. The data for the various processes of the control unit 17 is inputted by the keyboard 19 and the images photographed by the image recognizing cameras 16a and 16b and the process situations in the control unit 17 are displayed on the monitor 18. The data inputted by the keyboard 19 is sent to a memory medium like a floppy disc in the external memory unit of the PC body 20.

[0016] The light source 22 and the image recognizing unit 23 are formed on the support plate 15 with no help of the linear guide, unlike the paste storage receptacle 13 and the distance meter 14, and even through the servo motor 12 is rotated, they do not move in the direction of axis Z. The image outputted from the image recognizing unit 23 like the image taken by the image recognizing cameras 16a and 16b is processed in the control unit 17.

[0017] FIG. 2 is an enlarged perspective view showing the paste storage receptacle 13 and the distance meter 14 of FIG. 1, wherein reference numeral 13a

denotes a nozzle, and 24 denotes a substrate, wherein the parts corresponding to those of FIG. 1 are indicated by corresponding reference numerals.

[0018] As shown in FIG. 2, the distance meter 14 is provided at the lower end thereof with a triangular cut portion that has a light emitting diode and a plurality of light receiving diodes thereon. The nozzle 13a is positioned under the triangular cut portion of the distance meter 14. The distance meter 14 measures a distance from the front end portion of the nozzle 13a to the surface (top surface) of the substrate 24 by using a non-contact triangulation method.

[0019] That is, the light emitting diode is disposed at the one side inclined surface of the triangular cut portion, and laser light L emitted from the light emitting diode is reflected at a measuring point S on the substrate 24 and is received through any of the plurality of light receiving diodes on the other side inclined surface of the triangular cut portion. Therefore, the laser light L is not cut off by the formation of the paste storage receptacle 13 and the nozzle 13a.

[0020] On the other hand, the measuring point S of the substrate 24 at which the laser light L is reflected is misaligned by substantially short distances ΔX and ΔY

with the substrate 24 placed just under the nozzle 13a. Since the height (concave and convex) on the surface of the substrate 24 is relatively constant, even with having the distance differences ΔX and ΔY, there is little difference between the measured result of the distance meter 14 and the distance between the front end portion of the nozzle 13a and the surface of the substrate 24. As the servo motor 12 is controlled based upon the measuring result of the distance meter 14, the distance between the front end portion of the nozzle 13a and the surface (top surface) of the substrate 24 is constantly maintained according to the height of the surface of the substrate 24.

[0021] Thereby, as an amount of paste discharging from the nozzle 13a per unit time is constantly maintained, the width and thickness of the paste pattern coated on the substrate are all kept constant.

[0022] FIG. 3 is an enlarged perspective view showing the light source 22 and the image recognizing unit 23 formed on the support plate 15 of FIG. 1, wherein reference numeral 23a denotes an illuminator, 23b denotes an image recognizing

camera, and 23c denotes a body tube, wherein the parts corresponding to those of FIG. 1 are indicated by corresponding reference numerals.

[0023] As shown in FIG. 3, the light source 22 is formed on the support plate (support member) 15 of the nozzle 13a for irradiating cross-shaped slit light onto the paste pattern at an angle of depression of 45. degree. with respect to the surface of the substrate 24. When viewed at the front of FIG. 1, the cross of the slit light becomes X-shaped at the time of being irradiated on the surface of the substrate. That is, the cross is inclined at the angle of 45.degree. with respect to the directions of axes X and Y.

[0024] The image recognizing unit 23 has the round-shaped illuminator 23a for executing episcopic illumination with respect to the surface of the substrate 24, the image recognizing camera 23b for photographing the surface of the substrate 24 through the middle opening of the illuminator 23a, and the body tube 23c mounted to the image recognizing camera 23b. The optical axis of the image recognizing camera 23b is in a perpendicular relation to the surface of the substrate 24, through the center point of the middle opening of the illuminator 23a.

Since the light source 22 and the image recognizing camera 23b are fixed on the support plate 15, they conduct a focus alignment function toward the paste pattern being formed at an arbitrary height on the substrate 24.

[0025] The light source 22 irradiating the cross-shaped slit light and the illuminator 23a executing the episcopic illumination are used as the things capable of emitting illumination colors that can make the contrast of the image photographed by the image recognizing camera 23b substantially clear, in accordance with the characteristics of light reflection and dispersion on the substrate 24 and the paste.

[0026] FIG. 4 is a block diagram showing the construction of the control unit 17 of FIG. 1. Reference numeral 17a denotes a microcomputer, 17b denotes a motor controller, 17c denotes an X-axis driver, 17d denotes a Y-axis driver, 17e denotes a θ–axis driver, 17f denotes a Z-axis driver, 17g denotes an image processing unit, 17h denotes an external interface, 25 denotes a servo motor, and 26 to 29 denote encoders, wherein the parts corresponding to those of FIGS. 1 and 3 are indicated by corresponding reference numerals.

[0027] As shown in FIG. 4, the control unit 17 integrally has the microcomputer 17a, the motor controller 17b, the X, Y, Z and θ axes drivers 17c to 17f, the image processing unit 17g for processing the image signals obtained from the image recognizing cameras 16a, 16b, and 23b, and the external interface 17h for transmitting signals to the keyboard 19. The control unit 17 further includes a driving control system of the substrate returning conveyors 2a and 2b that is not shown in the drawing. The microcomputer 17a includes a read-only memory (ROM) in which a main operating part and a processing program for conducting the paste pattern to be coated as will be discussed later are stored, a random access memory (RAM) in which the process result of the main operating part and the input data from the external interface 17h and the motor controller 17b are stored, and an input and output part that exchanges the data with the external interface 17h and the motor controller 17b.

[0028] The servo motor 25 serves to drive the θ-axis movement table 5. The servo motors 8, 10, 12, and 25 mount corresponding encoders 26 to 29 for detecting the

amount of rotation. The detected results are sent to the X, Y, Z and θ axes drivers 17c to 17f through which position control is conducted.

[0029] As the servo motors 8 and 10 are rotated forwardly and backwardly based upon the data stored in the RAM of the microcomputer 17a inputted through the keyboard 19, the nozzle 13a (see FIG. 2) is moved by an arbitrary distance in the directions of the axes X and Y through the Z-axis movement table 9 (see FIG. 1), with respect to the substrate 24 (see FIG. 2 and FIG. 2) placed in vacuum sucking manner on the substrate sucking plate 4 (see FIG. 1). During the movement a relatively small amount of air pressure is applied to the paste storage receptacle 13, such that the paste is discharged from the outlet of the front end portion of the nozzle 13a and coated on the substrate 24 to a desired pattern. While the Z-axis movement table 9 is moved horizontally to the directions of the axes X and Y, the distance meter 14 measures the distance between the nozzle 13a and the substrate 24, and in order to maintain the distance constantly, the servo motor 12 is controlled by means of the Z-axis driver 17f.

[0030] Under the above construction, next, an explanation of the patterning process of the paste pattern and the measuring process of the paste pattern patterned is given with reference to FIG. 5.

[0031] As shown in FIG. 5, if power is applied to the paste coating device according to the present invention (at step 100), an initial setting starts (at step 200). In the initial setting process, the servo motors 8 and 10 as shown in FIG. 1 are driven to move the Z-axis movement table 9 in the directions of axes X and Y thus to a given reference position and set the nozzle 13a (see FIG. 2) to a given original position thus to determine a position (that is, a paste coating starting point) where the paste outlet of the nozzle starts to discharge the paste. At the same time, setting is conducted for paste pattern data, substrate position data, paste discharging ending position data, and measuring position data of the paste pattern formed. The input of the various kinds of data is executed by means of the keyboard 19 (see FIG. 1) and stored in the RAM in the microcomputer 17a (see FIG. 4).

[0032] If the initial setting processing ends (at step 200), the substrate 24 on which paste is coated to a desired shape is supportably placed on the substrate suction plate 4 (see FIG. 1) (at step 300). In the mounting process of the substrate 24, the substrate 24 is delivered upwardly of the substrate suction plate 4 in the direction of axis X through the substrate returning conveyors 2a and 2b (see FIG. 1) and is then placed on the substrate suction plate 4 as the substrate returning conveyors 2a and 2b are descended by means of an elevating device which is not shown.

[0033] Next, a substrate preparing position determining process (step 400) is executed. In this process, the substrate 24 is positioned in the directions of the axes X and Y by means of a position determining chuck which is not shown in FIG. 1. A position determining mark of the substrate 24 mounted on the substrate suction plate 4 is photographed by means of the image recognizing cameras 16a and 16b, and the weight center position of the position determining mark is obtained in an image process to detect an inclination of the substrate in the direction of θ. Thereby, the servo motor 25 (see FIG. 2) is driven to correct the inclination of the substrate in the direction of θ.

[0034] Moreover, if there is a possibility that as the amount of paste remaining in the paste storage receptacle 13 becomes smaller, the paste is all exhausted during the coating operation of the paste pattern, the paste storage receptacle 13 is previously exchanged, together with the nozzle 13a. When the nozzle 13a is exchanged, the position misalignment may be generated. Thus, dotting-patterning is executed at the position where the paste is not coated yet on the substrate 24 by using the new nozzle 13a. The weight center position of the dotting-patterning is obtained in the image process, and a distance between the weight center position of the dotting-patterning and the weight center position of the position determining mark of the substrate 24 is calculated. The distance is set as amounts of the position misalignment dx and dy of the paste outlet of the nozzle 13a and then stored in the RAM of the microcomputer 17a. Thereby, the substrate preparing position determining process (the step 400) for the substrate 24 is finished, and the position misalignment of the nozzle 13a upon coating of the paste pattern to be executed later is corrected by using the amounts of the position misalignment dx and dy of the nozzle 13a.

[0035] Next, the paste coating film forming process (at step 500) is executed. In this process, the Z-axis movement table 9 is moved to execute comparing and adjusting movements of the nozzle 13a, such that the outlet of the nozzle 13a is positioned at the coating starting position.

[0036] Before this process, it is first determined that the amounts of the position misalignment dx and dy of the nozzle 13a that are obtained in the substrate preparing position determining process (at the step 400) and stored in the RAM of the microcomputer 17a are in the allowable range values ΔX and ΔY of the amounts of the position misalignment of the nozzle 13a in FIG. 2. If the amounts of the position misalignment dx and dy of the nozzle 13a is in the allowable range (that is, if $\Delta X \geq dx$ and $\Delta Y \geq dy$), the position of nozzle is determined at the coating starting position, without any movement. Contrarily, if the amounts of the position misalignment dx and dy of the nozzle 13a are not in the allowable range (that is, if $\Delta X < dx$ and $\Delta Y < dy$), the Z-axis movement table 9 is moved based upon the amounts of the position misalignment dx and dy of the nozzle 13a, to adjust the position of the paste storage receptacle 13, such that the misalignment between

the outlet of the nozzle 13a and the desired position of the substrate 24 is removed thus to position the nozzle 13a at the desired position.

[0037] Next, the height setting of the nozzle 13a is executed. When the paste storage receptacle 13 is not exchanged, the data of the amounts of the position misalignment dx and dy of the nozzle 13a does not exist and thus, when the paste coating film forming process (at the step 500) starts, the height setting of the nozzle 13a is just conducted. The set height is the paste thickness from the outlet of the nozzle 13a to the surface of the substrate 24.

[0038] When the above process is finished, next, the servo motors 8 and 10 are driven based upon the paste pattern data stored in the RAM of the microcomputer 17a, and thereby, the nozzle 13a is moved in the directions of axes X and Y on the basis of the paste pattern data, facing the outlet against the substrate 24. At the same time, an air pressure is a little applied to the paste storage receptacle 13 such that the paste starts to be discharged from the outlet of the nozzle 13a. Thereby, the paste pattern coating and patterning process starts on the substrate 24.

[0039] Together with the patterning of the paste pattern, the data of distance between the outlet of the nozzle 13a and the surface of the substrate 24 that is obtained by using the distance meter 14 is inputted to the microcomputer 17a to thereby measure the height of the surface of the substrate 24. The servo motor 12 is driven based upon the measured height value, such that the set height of the nozzle 13a from the surface of the substrate 24 is kept constantly, thereby conducting the coating and patterning of the paste pattern.

[0040] The coating and patterning of the paste pattern is kept on, and it is determined whether the coating and patterning operation of the paste pattern is finished with respect to the paste pattern data. Based upon the determined result, it is determined that the paste discharging from the paste storage receptacle 13 is continued or stops.

[0041] In this paste coating film forming process (at the step 500), it is determined whether the coated point is an ending point of the paste pattern to be coated determined by the paste pattern data. If the coated point is not the ending point, the measuring process of the height of the surface of the substrate 24 is executed

again, and next, each process as discussed above is repeated until the coated point reaches the coating ending of the paste pattern. If the coated point reaches the coating ending of the paste pattern, the servo motor 12 is driven to ascend the nozzle 13a. Thus, the paste coating film forming process (at the step 500) is finished.

[0042] Next, the process of measuring the paste pattern on which the patterning process has been finished (at step 600).

[0043] As shown in FIG. 6, the paste pattern PP has been formed on the substrate 24, and it is assumed that it is formed of ㅁ–shaped pattern that is rounded on their corners.

[0044] In this case, it is assumed that the surface is the surface of the substrate 24 on which the paste pattern PP is formed, and the slit light that is passed through the cross-shaped slit is irradiated to the paste pattern PP at an angle of depression of 45.degree. obliquely upwardly in a left direction with respect to the surface by using the light source 22 as shown in FIG. 3. In this case, since the paste pattern PP has a curved surface thereon, the cross-shaped marks are

irradiated, as shown by the solid lines of FIG. 6, on the round corner portions a to d and straight line portions e to h of the paste pattern PP, with a result that they are distorted in the shapes. The slit light reflected from the corner portions a to d and the straight line portions e to h of the paste pattern PP is received to allow the image recognizing camera 23b to photograph the portions on which the cross-shaped slit marks are contained.

[0045] In FIG. 6, the cross-shaped slit marks that are irradiated to the corner portions a to d and the straight line portions e to h of the paste pattern PP are displayed at a time, but actually, the cross-shaped slit mark is irradiated to all of the portions one by one and is photographed by the image recognizing camera 23b. As will be discussed below, the paste pattern PP on which the cross-shaped slit mark is irradiated is measured to obtain the height. To do the measurement, the X-axis movement tables 6a and 6b and the Y-axis movement table 7 as shown in FIG. 1 are driven by means of the servo motors 8 and 10, such that the image recognizing camera 23b secured on the support plate 15 is moved to a position where the height of the paste pattern PP formed on the substrate 24 is measured

to thereby photograph the image thereof. So as to place the axis of the slit light in parallel or orthogonal relation to the straight line portions of the paste pattern PP, the direction of the substrate 24 is adjusted by means of the θ -axis movement table 5 as shown in FIG. 1.

[0046] Next, an explanation of the measurement of the height of the paste pattern PP at the corner portions a to d is given below.

[0047] The corner portions a to d have different slit light by 45.degree. from one another, but since the operation principles of the heights are the same as one another, the measuring process of the height of the paste pattern PP especially at the corner portion a is discussed with reference to FIG. 7.

[0048] As shown in FIG. 7(a), the cross-shaped slit mark is irradiated to place the intersection to be aligned with the highest point of the paste pattern PP. In this case, the one straight line of the cross-shaped slit mark is irradiated along the ridge of the paste pattern PP, and the other thereof is irradiated to cross the paste pattern PP. Thus, as shown, the one straight line of the cross-shaped slit mark is irradiated in a straight line along the ridge of the paste pattern PP, and the other

thereof is irradiated in a curved line to cross the paste pattern PP. As noted in FIG. 3, the portion of the substrate 24 on which the cross-shaped slit mark is irradiated is illuminated by means of the illuminator 23a, and the illuminated portion is photographed by means of the image recognizing camera 23b. Thereby, the image is obtained as shown in FIG. 7(a).

[0049] In FIG. 7(a), a symbol T represents the highest position of the paste pattern on the image where the intersection of the two straight lines of the cross-shaped slit mark M is irradiated, and symbols E1 and E2 are the positions of image where the one straight line of the cross-shaped slit mark crosses the end peripheries of the paste pattern PP. In this case, the straight line shown in a dotted line on the image, which connects the positions E1 and E2, is denoted by L1, the line that is extended from the position T to the straight line L1 in the direction of irradiation of the cross-shaped slit mark M is denoted by PL1, and the intersection between the straight line L1 and the line PL1 is denoted by CP1.

[0050] FIG. 7(b) depicts the sectional view on the substrate 24 taken along the line PL1 of FIG. 7(a).

[0051] In FIG. 7(b), since the image recognizing camera 23b conducts the photographing just upwardly of the portion of the paste pattern PP to which the cross-shaped slit mark M is irradiated, in the case where the image shown in FIG. 7(a) is obtained by the image recognizing camera 23b, a point TP of the surface of the paste pattern PP just above the position T is the highest position of the paste pattern when it is assumed that the position T of FIG. 7(a) is placed on the substrate 24 in the sectional view of FIG. 7(b). The intersection of the cross-shaped slit mark M is irradiated to the highest point TP. The positions E1 and E2 of FIG. 7(a) are placed on the substrate 24. Therefore, the straight line L1 connecting the positions E1 and E2 is placed on the substrate 24, and the intersection CP1 on the straight line L1 is placed on the substrate 24.

[0052] On the other hand, when considering the plane on which the highest point TP of the paste pattern PP and the positions E1 and E2 of FIG. 7(a) are contained, the highest point TP of the paste pattern PP and the positions E1 and E2 are obtained by irradiating the points on the one straight line of the cross-shaped slit mark M, such that the plane is placed in parallel relation to the axis of the slit light.

Therefore, in FIG. 7(b), the straight line connecting the highest point TP of the paste pattern PP and the intersection CP1 on the substrate 24 is placed in parallel relation to the axis of the slit light, and as discussed above, since the axis of the slit light is formed at an angle of 45.degree. with respect to the surface of the substrate 24, the triangle formed by the positions TP, CP1 and T becomes a right-angled isosceles triangle. Thus, the distance between the positions T and CP1 is equal to the distance between the positions TP and T, that is, the height of the paste pattern PP.

[0053] In the image as shown in FIG. 7(a) obtained by the image recognizing camera 23b, the distance between the positions T and CP1 that is equal to the length of the line PL1 is obtained, with a result of detecting the height of the paste pattern PP.

[0054] The width of each of the corner portions a to d of the paste pattern PP is equal to the distance between the positions E1 and E2, as shown in FIG. 7(a), and thus, the width can be easily detected.

[0055] FIG. 8(a) depicts a method for measuring the height of the paste pattern at the straight line portions e to h, wherein the measuring process is carried out especially at the straight line portion f.

[0056] In this case, the process is carried out in the same manner as the corner portions of the paste pattern PP, but, as shown in FIG. 8(a), the slit light of the cross-shaped slit mark is irradiated at the angle of depression of 45.degree. in the direction of length of the paste pattern PP. In the same manner as the corner portions of the paste pattern PP, the cross-shaped slit mark M is irradiated to place the intersection to be aligned with the highest point of the paste pattern PP. In this case, the two straight lines of the cross-shaped slit mark M are irradiated to cross the paste pattern PP at an inclination of 45.degree.. Thereby, the irradiated two straight lines become the curved lines on the paste pattern PP, as shown.

[0057] The irradiated mark portion is photographed by means of the image recognizing camera 23b. Thereby, the image is obtained as shown in FIG. 8(a). In the same manner as in FIG. 7(a), the symbol T represents the highest position of the paste pattern PP on the image where the intersection of the two straight lines

of the cross-shaped slit mark M is irradiated, and symbols E3 and E4 are the positions of image where the one straight line of the cross-shaped slit mark M intersects the boundaries between the paste pattern PP and the substrate 24. In this case, the straight line shown in a dotted line on the image, which connects the positions E3 and E4, is denoted by L2, the line that is extended from the position T on the image to the straight line L2 in the direction of irradiation of the cross-shaped slit mark M is denoted by PL2, and the intersection between the straight line L2 and the line PL2 is denoted by CP2.

[0058] FIG. 8(b) depicts the sectional view on the substrate 24 taken along the line PL2 of FIG. 8(a).

[0059] In FIG. 8(b), in the same manner as in FIG. 7(b), the triangle formed by the highest position TP of the paste pattern PP, the intersection CP1, and the position T becomes a right-angled isosceles triangle. Thus, the distance between the positions T and CP2 is equal to the distance between the positions TP and T, that is, the height of the paste pattern PP. Therefore, in the image as shown in FIG.

8(a) obtained by the image recognizing camera 23b when the vertical line PL2 of the image is obtained, the height of the paste pattern PP is detected.

[0060] Under the above-mentioned process, the height of the paste pattern PP is obtained, but in this way, it is actually difficult to align the intersection of the cross-shaped slit mark M with the highest position TP of the paste pattern PP with high precision, which of course causes the efficiency of working tact to be low. Thereby, the height of the paste pattern PP can be obtained with variation of the above-mentioned method, as will be discussed below. The variation is explained with reference to FIG. 9.

[0061] (1)First, the cross-shaped slit mark M is appropriately irradiated on the paste pattern PP and photographed by using the image recognizing camera 23b. In this case of the irradiation, at least one of the two straight lines of the cross-shaped slit mark M intersects the paste pattern PP.

(2) In the image obtained above, the positions E5 and E6 on the image where the image of the cross-shaped slit mark M intersects the end peripheries of the paste pattern PP are determined by the image processing unit 17g.

(3) After that, the center point NP of the positions E5 and E6 is obtained, and an imaginary line NL is made to pass through the center point NP in parallel relation to the paste pattern PP.

(4) Brightness values are obtained with respect to each picture element on the imaginary line NL to thereby select brightest one among them, which is determined as the position T on the image of the highest position TP of the paste pattern PP. This is based upon that the center in the direction of width of the paste pattern PP is placed at the highest position.

(5) Next, a straight line L3 connecting the positions E5 and E6 on the image is made and then, it is extended from the position T in the direction of irradiation of the cross-shaped slit mark M, thus forming the line PL3. Then, the intersection CP3 between the line PL3 and the straight line L3 is obtained, and the distance between the position T and the intersection CP3 is obtained, in the same manner as in FIGS. 7 and 8. The obtained distance becomes the height of the paste pattern PP. The intersection CP3 is the position on the image where the crossed axis of the slit light intersects the surface of the substrate.

[0062] Under the above process, the arbitrary height of the paste pattern PP is measured. In the case of the straight line portion f of FIG. 8(a) as one example, the width is obtained with ease by using trigonometric function from the distance of the straight line connecting the positions E3 and E4 and the inclined angle with respect to the paste pattern PP of the straight line connecting the positions E1 and E2.

[0063] The above-discussed process is the pattern measuring process (step 600) in FIG. 5, and if the process is finished, a quality determined process (at step 700) of the paste pattern formed on the substrate is executed. In the quality determining process, the determining reference data of the height stored in the RAM of the microcomputer 17a (see FIG. 4) is compared with the data of the height and width of the paste pattern PP obtained in the paste pattern measuring process (at the step 600), and it is determined whether the height and width of the paste pattern PP are in a prescribed range.

[0064] If it is determined that the substrate on which the paste pattern P is formed is a good quality of product in the quality determining process (at the step 700),

next, a substrate separating process (at step 900) is executed. In this process, the suction of the substrate 24 by the substrate suction plate 4 is released, and the substrate returning conveyors 2a and 2b are ascended such that the substrate 24 is placed on the substrate returning conveyors 2a and 2b and is moved to the outside of the device. Contrarily, if it is determined that the substrate on which the paste pattern P is formed is a bad quality of product (at the step 700), the substrate is eliminated from the product line system and has a bad product process (at step 800).

[0065] And, it is determined whether all of the above-discussed processes are finished (at step 1000), and in a case where the paste pattern is coated by using the same paste pattern data on a plurality of substrate sheets, the substrate mounting process (at the step 300) is applied to another substrate. When the series of processes are finished for all of the substrates, the operation is completely finished (at the step 1000).

[0066] In the preferred embodiment of the present invention, the paste pattern that is formed by means of the nozzle 13a is photographed by using the image

recognizing camera at a time, and next, the height of the paste pattern is measured by using the image processing unit, such that the measuring errors do not exist, the measuring process is executed at a relatively high speed, and the efficiency of the working tact is not lowered.

[0067] Furthermore, in the preferred embodiment of the present invention, the paste pattern that is formed by the nozzle 13a is photographed by the image recognizing camera 23b that is just adjacent thereto, such that even though the paste has a low viscosity and is thus easily changed in shape when inclined, the paste pattern just after the patterning can be accurately measured.

[0068] Moreover, in the preferred embodiment of the present invention, the cross-shaped slit mark is employed in consideration of the paste patterns having all shapes, but the present invention is not limited thereto. For example, a straight line-shaped slit mark may be used

[0069] The irradiation angle of the slit light is 45.degree., but this is because the right-angled isosceles triangle is obtained from the image photographed and the height of the paste pattern is easily detected. Since the right-angled triangle is of

course obtained at different angles, therefore, the irradiation angle of the slit light may be selected arbitrarily.

[0070] Like the conventional paste coating device, also, it is possible that the image recognizing camera 23b is fixed horizontally together with the nozzle 13a and the distance meter 14 and the substrate is moved horizontally.

[0071]

[Effect of the Invention]

As set forth in the foregoing, according to the present invention, a paste coating device can measure all various paste patterns formed on the substrate with precision and at a substantially high velocity, irrespective of the shapes of the paste patterns.

[Description of Drawings]

FIG. 1 is a perspective view showing the structure of a paste coating device according to the present invention.

FIG. 2 is an enlarged perspective view showing the paste storage receptacle and the distance meter of FIG. 1.

FIG. 3 is a perspective view showing the position relation of the image recognizing unit in the paste coating device of FIG. 1.

FIG. 4 is a block diagram showing a control system of FIG. 1.

FIG. 5 is a flowchart showing the whole operation of the paste coating device of FIG. 1.

FIG. 6 is a view showing the paste pattern formed on the substrate and the example of cross-shaped slit marks irradiated to each position on the paste pattern in the paste coating device of FIG. 1.

FIG. 7 is a view showing one example of a method of measuring the height of the paste pattern shown in FIG. 6 in the paste coating device of FIG. 1.

FIG. 8 is a view showing another example of a method of measuring the height of the paste pattern shown in FIG. 6 in the paste coating device of FIG. 1.

FIG. 9 is a view showing still another example of a method of measuring the height of the paste pattern shown in FIG. 6 in the paste coating device of FIG. 1.

[Description of Reference Numerals]

1: mount

2a, 2b: substrate returning conveyors

3:support stand

4: substrate suction plate

5: θ -axis movement table

6a, 6b: X-axis movement tables

7: Y-axis movement table

8: servo motor

9: Z-axis movement table

10, 12: servo motors

13: paste storage receptacle

13a: nozzle

15: support plate

17: control unit

17g: image processing unit

25: servo motor

22: light source

23: image recognizing unit

23a: episcopic illuminator

23b: image recognizing camera

23c: body tube

24: substrate

PP: paste pattern